

What is claimed is:

1 1. A phaser for adjusting timing between a camshaft and a timing gear coupled to a
2 crankshaft of an engine, comprising:

3 a rotor having a plurality of circumferentially spaced apart vanes and a central
4 cylindrical recess located along an axis of rotation, the rotor being
5 connectable to the camshaft for rotation therewith;

6 a housing connectable to the timing gear for rotation therewith, having a body
7 coaxially surrounding the rotor, the body having a plurality of recesses
8 circumferentially spaced apart for receiving the vanes of the rotor, and
9 permitting rotational movement of the vanes therein, wherein each of the
10 vanes divides one of the recesses into a first portion and a second portion,
11 the first portion and the second portion of the recesses being capable of
12 sustaining fluid pressure, such that introduction of a fluid under pressure
13 into the first portion causes the rotor to move in a first rotational direction
14 relative to the housing and introduction of a fluid under pressure into the
15 second portion causes the rotor to move in an opposite rotational direction
16 relative to the housing;

17 a spool located within the cylindrical recess of the rotor and being slidably
18 movable along the axis of rotation of the rotor, the spool comprising a
19 plurality of lands which block and connect a plurality of passageways in the
20 rotor, such that by slidably moving the spool in the cylindrical recess of the
21 rotor, the flow of fluid from a fluid input to the first portion and the second
22 portion is controlled, varying the rotational movement of the housing
23 relative to the rotor; and

24 an inlet check valve located in the rotor, wherein the inlet check valve controls a
25 backflow of fluid entering the fluid input.

1 2. The phaser of claim 1, in which:

2 the spool comprises length and a first land and a second land, spaced apart a
3 distance along the length, such that the first land and the second land have a
4 circumference which provides a fluid blocking fit in the cylindrical recess,
5 and the length has a lesser circumference than the first land and second land
6 to permit fluid to flow; and

7 the cylindrical recess of the rotor comprising, in spaced-apart relationship along a
8 length of the cylindrical recess from a first end of the cylindrical recess
9 most distant from the camshaft to a second end of the cylindrical recess
10 closest to the camshaft:

11 a first exhaust vent connecting the cylindrical recess to atmosphere;

12 a first return line connecting the first portion to the cylindrical recess;

13 a first movement line connecting the cylindrical recess to the first portion;

14 a central inlet line connecting a central location in the cylindrical recess to a
15 source of fluid;

16 a second movement line connecting the cylindrical recess to the second
17 portion;

18 a second return line connecting the second portion to the cylindrical recess;

19 a second exhaust vent connecting the cylindrical recess to atmosphere;

20 the first exhaust vent, second exhaust vent, first return line, second return line, first
21 movement line, second movement line and central inlet line being spaced
22 apart along the length of the cylindrical recess, and the first land and the
23 second land being of sufficient length and distance apart such that:

24 when the spool is in a central position between the first end of the central
25 recess and the second end of the central recess, the first land blocks
26 the first return line and the first movement line, and the second land
27 blocks the second movement line and the second return line;

28 when the spool is in a position nearer the first end of the central recess, the
29 first movement line and second return line are unblocked, fluid from
30 the central inlet line flows into the first movement line and the first
31 portion, and fluid from the second portion flows into the second
32 return line and the second exhaust vent; and

33 when the spool is in a position nearer the second end of the central recess,
34 the second movement line and first return line are unblocked, fluid
35 from the central inlet line flows into the second movement line and
36 the second portion, and fluid from the first portion flows into the
37 first return line and the first exhaust vent.

1 3. The phaser of claim 1, further comprising a variable force actuator, such that the
2 variable force actuator controls the position of the spool in response to a signal
3 issued from an engine control unit.

1 4. The phaser of claim 3, wherein the variable force actuator is an electromechanical
2 variable force solenoid.

1 5. The phaser of claim 4, further comprising a spring for biasing the spool valve to a full
2 advance position during periods when the electromechanical variable force
3 solenoid is deenergized.

1 6. The phaser of claim 3, wherein the variable force actuator is a pulse-width modulated
2 solenoid.

1 7. The phaser of claim 1, wherein the fluid comprises engine lubricating oil.

1 8. An internal combustion engine, comprising:

2 a crankshaft, the crankshaft being rotatable about a first axis;

3 a camshaft, the camshaft being rotatable about a second axis, the camshaft being
4 subject to torque reversals during rotation thereof;

5 a phaser for adjusting timing between a camshaft and a timing gear coupled to a
6 crankshaft of an engine, comprising:

7 a rotor having a plurality of circumferentially spaced apart vanes and a
8 central cylindrical recess located along an axis of rotation, the rotor
9 being connectable to the camshaft for rotation therewith;

10 a housing connectable to the timing gear for rotation therewith, having a
11 body coaxially surrounding the rotor, the body having a plurality of
12 recesses circumferentially spaced apart for receiving the vanes of
13 the rotor, and permitting rotational movement of the vanes therein,
14 wherein each of the vanes divides one of the recesses into a first
15 portion and a second portion, the first portion and the second
16 portion of the recesses being capable of sustaining fluid pressure,
17 such that introduction of a fluid under pressure into the first portion
18 causes the rotor to move in a first rotational direction relative to the
19 housing and introduction of a fluid under pressure into the second
20 portion causes the rotor to move in an opposite rotational direction
21 relative to the housing;

22 a spool located within the cylindrical recess of the rotor and being slidably
23 movable along the axis of rotation of the rotor, the spool comprising
24 a plurality of lands which block and connect a plurality of
25 passageways in the rotor, such that by slidably moving the spool in
26 the cylindrical recess of the rotor, the flow of fluid from a fluid
27 input to the first portion and the second portion is controlled,
28 varying the rotational movement of the housing relative to the rotor;

29 an electromechanical actuator mechanically coupled to the spool;

30 an engine control unit coupled to the electromechanical actuator, such that ,
31 the electromechanical actuator controls the position of the spool in
32 response to a signal issued from the engine control unit; and

33 an inlet check valve located in the rotor, wherein the inlet check valve
34 controls a backflow of fluid entering the fluid input.

1 9. The internal combustion engine of claim 8, in which:

2 the spool comprises length and a first land and a second land, spaced apart a
3 distance along the length, such that the first land and the second land have a
4 circumference which provides a fluid blocking fit in the cylindrical recess,
5 and the length has a lesser circumference than the first land and second land
6 to permit fluid to flow; and

7 the cylindrical recess of the rotor comprising, in spaced-apart relationship along a
8 length of the cylindrical recess from a first end of the cylindrical recess
9 most distant from the camshaft to a second end of the cylindrical recess
10 closest to the camshaft:

11 a first exhaust vent connecting the cylindrical recess to atmosphere;

12 a first return line connecting the first portion to the cylindrical recess;

13 a first movement line connecting the cylindrical recess to the first portion;

14 a central inlet line connecting a central location in the cylindrical recess to a
15 source of fluid;

16 a second movement line connecting the cylindrical recess to the second
17 portion;

18 a second return line connecting the second portion to the cylindrical recess;

19 a second exhaust vent connecting the cylindrical recess to atmosphere;

20 the first exhaust vent, second exhaust vent, first return line, second return line, first
21 movement line, second movement line and central inlet line being spaced
22 apart along the length of the cylindrical recess, and the first land and the
23 second land being of sufficient length and distance apart such that:

24 when the spool is in a central position between the first end of the central
25 recess and the second end of the central recess, the first land blocks
26 the first return line and the first movement line, and the second land
27 blocks the second movement line and the second return line;

28 when the spool is in a position nearer the first end of the central recess, the
29 first movement line and second return line are unblocked, fluid from
30 the central inlet line flows into the first movement line and the first
31 portion, and fluid from the second portion flows into the second
32 return line and the second exhaust vent; and

33 when the spool is in a position nearer the second end of the central recess,
34 the second movement line and first return line are unblocked, fluid
35 from the central inlet line flows into the second movement line and
36 the second portion, and fluid from the first portion flows into the
37 first return line and the first exhaust vent.

1 10. The internal combustion engine of claim 8, further comprising a variable force
2 actuator, such that the variable force actuator controls the position of the spool in
3 response to a signal issued from an engine control unit.

1 11. The internal combustion engine of claim 10, wherein the variable force actuator is an
2 electromechanical variable force solenoid.

1 12. The internal combustion engine of claim 11, further comprising a spring for biasing
2 the spool valve to a full advance position during periods when the
3 electromechanical variable force solenoid is deenergized.

1 13. The internal combustion engine of claim 10, wherein the variable force actuator is a
2 pulse-width modulated solenoid.

1 14. The internal combustion engine of claim 8, wherein the fluid comprises engine
2 lubricating oil.